

WEAK LOW-FREQUENCY ELECTROMAGNETIC OSCILLATIONS IN WATER

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Abstract

Recent observations of low-frequency electromagnetic oscillations in water suggest an inductive structural component. Accordingly we assume a helical basis enabling us to model water as an LC tuned oscillator. A proposed tetrahedral structure consisting of three water molecules and one hydronium ion is incorporated into the Boerdijk-Coxeter tetrahelix to form long water chains that are shown to have resonance frequencies consistent with observation. This model also serves to explain separately reported claims of ion cyclotron resonance of hydronium ions, in that the tetrahelix provides a built-in path for helical proton-hopping.

Keywords. Water structure, Boerdijk-Coxeter tetrahelix, Tuned oscillator, Proton-hopping, Hydronium ion cyclotron resonance.

Introduction. In the following we explore the possibility that water can sustain internal electromagnetic oscillations independent of any simultaneously applied external electromagnetic field. To this end a putative water structure is proposed that appears capable of maintaining such oscillations.

A number of reports have focused on the electromagnetic characteristics of water, usually under conditions where background fields were severely reduced by shielding. These studies followed the discovery (Zhadin et al, 1998) that the conductivity of polar amino acid (glu^+) in aqueous solution is enhanced under ion cyclotron resonance (ICR) combined magnetic fields (Liboff, 1985). This discovery is all the more remarkable because of the vanishingly small AC magnetic intensity that was used, 40 nT. Subsequently, weak ELF magnetic fields were shown (Novikov and Fesenko, 2001) to cause protein hydrolysis, a result that indirectly implicated the involvement of water. To explain these varied experimental results Del Giudice et al (2002) published the aptly named article *On the unreasonable effects of ELF magnetic fields upon a system of ions*, summarizing earlier quantum electrodynamic studies (Del Giudice et al, 1988). that first, predicted the

existence of 10 μm coherent domains (CD) in water, and second, used these domains to provide a reasonable explanation for ICR phenomena.

A group headed up by Montagnier (Montagnier et al, 2009) reported that highly diluted aqueous samples of DNA can imprint their characteristics on water and that these can subsequently be transmitted to external samples of pure water. Regardless of the implications regarding DNA imprinting in water these claims rest on the observation that water is capable of emitting ELF electromagnetic signals.

In two separate instances, clear evidence was found indicating electromagnetic oscillations in water. Following a 36 GHz signal irradiation of water two distinct AC electric field frequencies were observed at 5.25 Hz and 46.8 Hz, both signals persisting for tens of minutes (Fesenko and Gluvstein, 1995). More recently D’Emilia et al (2015) demonstrated in a highly shielded room with magnetic environment ≤ 10 nT that water which is first exposed to the hydronium ion ICR magnetic field condition tends to subsequently emit a very weak 48.5 Hz magnetic field, again persisting for tens of minutes. It is interesting that these oscillations are induced not by any one frequency but by widely disparate frequencies. As such we consider it likely that the oscillatory condition does not stem from any specific ICR resonance but instead reflects changes in electric polarization in water due to the application of an external electromagnetic field. Further, because the oscillatory signal measured was clearly damped in both Fesenko and Gluvstein (1995) and in D’Emilia et al (2015), it is probable that some degree of structural reordering accompanies this change in electric polarization.

Water as a Tuned Oscillator. We ask whether it is possible to work backwards from the experimentally observed “tuned frequency” (i.e., 46.8-48.5 Hz) to learn more about the form of water structure that gives rise to this frequency. To approach this problem one can model the system in terms of a broadly distributed inductance and capacitance, such that at resonance the frequency of the system is given by the familiar expression for the resonant frequency in a tuned circuit.

$$f_o = \frac{1}{2\pi\sqrt{LC}} \quad (1)$$

We assume that the inductance L and capacitance C in this expression correspond to a cylinder of length l and cross-sectional area A, as shown in Fig. 1.



Fig. 1. Geometrical parameters associated with a cylindrical volume of water.

The capacitance C of this cylinder is given as $C = \epsilon A/l$, where $\epsilon = k_e \epsilon_0$, ϵ_0 is the permittivity of free space, and k_e is the (dimensionless) dielectric constant within the cylinder. For pure water $k_e = 80$, resulting in $C = 80 \epsilon_0 A/l$.

Estimating the inductance L for the cylinder requires some extra thought. Ordinarily one does not associate inductance with water, but we have already raised the possibility that water may be capable of sustaining electromagnetic oscillations, a phenomenon that could readily imply inductance as an associated physical property. This would be the case, for example, if current-carrying helical configurations were part of the overall water structure. In the following we seek to develop a suitable expression for the inductance of such helical substructures.

In general, the inductance of a helical coil of length l is given as $L = \mu_0 n^2 a l$, where a is the cross-sectional area of the coil, n is the number of turns per unit length, and μ_0 is the permeability of free space. Although the length of this helix is the same as the cylinder in Fig. 1, we have deliberately chosen a to only be a fraction of A , such that $A = N a$. This is equivalent to the cylinder containing N parallel helices, each with cross-section a . Each of these helices will have a corresponding capacitance $80 \epsilon_0 a/l$.

This enables us to form the product LC for this single helix, obtaining $LC = 80 (n^2 a^2 / c^2)$, where use has been made of the fundamental expression involving the velocity of light c , namely $c^2 = 1/(\epsilon_0 \mu_0)$. What results is an alternate formula for the resonance frequency from that given in Eq.1, with the independent variables now expressed solely in terms of the structural parameters n and a .

$$f_o = \frac{c}{2\pi na\sqrt{80}} \quad (2)$$

The Water Tetrahelix. The mobility of the hydronium ion in water is greatly enhanced by the Grotthaus mechanism, also known as proton-hopping (Agmon, 1995; Hassanali et al, 2013). This mechanism can be thought of in terms of *water wires*, conduction paths along which H_3O^+ is transported. Although this may be a convenient description for cations in an electric field, where the drift velocity is only in one direction, the motion of a charged particle in a magnetic field is determined by the Lorentz force, which implies circular or helical paths. With this in mind, we argue that structural configurations in water that might allow helical paths should be particularly useful in looking for magnetic interactions in water.

It has been suggested (Kuhne and Khaliullin, 2013) that there is a tetrahedral component to water, a concept that found support in an experimental observation by D’Emilia et al (2016), who proposed the configuration shown in Fig. 2.

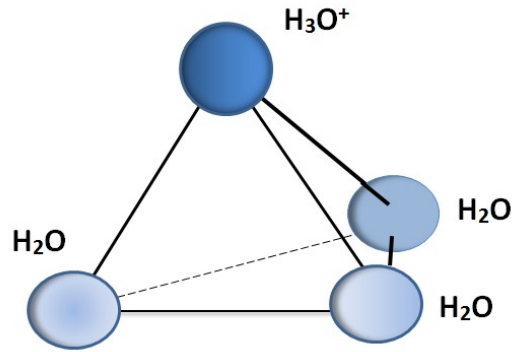


Fig. 2. Basic tetrahedral configuration proposed for water, with estimated edge length $3 \text{ \AA}$.

We make use of this tetrahedral arrangement, introducing the Boerdijk–Coxeter (BC) tetrahelix (Lord and Ranganathan, 2004). This is formed by linking each individual tetrahedron to its adjoining neighbor so as to form either a right-handed or left-handed chain of face-bonded tetrahedra (Fig. 3). We suggest that water can take this form, provided that a water molecule occupies each vertex, except for those vertices where a hydronium ion is found. Among the associated structural properties in this type of water one

finds three helices each formed by connecting successive vertices and each enjoying an approximate period corresponding to 27 successive tetrahedral interfaces (Gray, 2013).

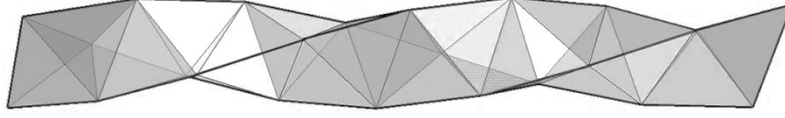


Fig. 3. Boerdijk-Coxeter tetrahelix made up of successive tetrahedra. Note that the structure includes three independent helices.

It is pointed out that the path described by each of these three helices can be thought of as the magnetic field analog to the usual proton-hopping drift movement in an electric field. In other words this helical structure enables a helical proton-hopping path in the presence of a magnetic field, where this path follows any one of the three associated helices.

One great advantage in applying the Boerdijk-Coxeter tetrahelical model is that the values of n and a in Eq. 2 are both predicted geometrically in terms of the real-world value of the edge length η of the 4-water tetrahedron shown in Fig. 2. The characteristics of the BC tetrahelix (Gray, 2013) include a helical period equal to $(27/\sqrt{10})\eta$ and a radius of $(3\sqrt{3}/10)\eta$, resulting in $n = 3.9 \times 10^9 \text{ m}^{-1}$ and $a = 7.6 \times 10^{-20} \text{ m}^2$.

To extend this model to a larger number of N identical parallel helices using this product na , we can use the resonant frequency

$$f_o = \frac{c}{2\pi N^2 na \sqrt{80}} \quad (3)$$

with the understanding that the new cross-sectional area is now $A = Na$ and the number of turns per unit length is now Nn . This enables us to estimate that the observed resonant frequency of 50 Hz corresponds to approximately 2×10^7 individual water helices, with an overall diameter on the order of cms. This is consistent with the fact that the frequencies 46.8 Hz and 48.5 Hz, observed respectively by Fesenko and Gluvstein (1995) and by D'Emilia et al (2015), were obtained using commensurate laboratory- sized water samples. In this connection note that the resonant frequency f_o varies sharply, as the inverse square of the sample size.

Discussion. This model provides an immediate explanation as to why cyclotron resonance coupling is observed for the hydronium ion. Instead of

the usual paths for proton-hopping often reported for H_3O^+ conduction in water, the water tetrahelix provides a helical hopping path for ions moving under the influence of a resonant magnetic field. Thus the tetrahelix explains two separate resonance phenomena in water, the size-dependent “natural” oscillations as well as the size-independent hydronium ion cyclotron resonance, the former resulting from prior electric polarization and the latter from the application of a properly tuned magnetic field.

Although we chose to include only one hydronium ion in the tetrahedron shown in Fig. 2, it is apparent that the same configuration could also include two, and perhaps even three or four H_3O^+ ions, with proportionately fewer waters. This change would affect n , the number of turns per unit length, because then one would have to include the other one or two BC helices. This reflects the fact that the three helices shown in Fig. 3 always intersect 3 of the four vertices in each tetrahedron, and the inductive quality of each vertice is limited to those that are positively charged.

One interesting question is whether there are any constraints on water molecules that might prevent the chemical organization indicated in Fig. 3. For one thing it is not clear that this highly organized structure can remain stable at room temperature. On the other hand one can readily imagine large numbers of such helices held together by hydrogen bonds. It can also be argued that the stability of such structures is dependent on as yet unrecognized but critical hydrogen-bond cooperativity extending over more crystalline structures. In this regard one important experimental observation is that to achieve meaningful results in water the experimental protocol always requires considerable shielding against the electromagnetic background. In essence these water experiments appear to be constrained by intensity windows, as evidenced by Fesenko and Gluvstein (1995) when they reported much stronger water oscillations when the exciting electromagnetic was reduced by a factor of 100.

The structure of water is currently of some interest, in part because of Del Giudice’s **concept of** coherent domains (Del Giudice et al, 2002), but also because of considerable evidence (Pollack, 2013) indicating that water may in fact exhibit an exclusion zone (EZ) phase, characterized by both higher density and a surplus of negative charge. The helical structure we propose bears some resemblance to EZ water, in that it likely is more viscous, but it is also very different since it is positively charged. On the other hand

nowhere in our discussion has any thought been given to the OH^- hydroxyl ions that must surely be present and their relation to the overall helical structure. Nor has the interactive nature of ionic impurities been considered, leaving unanswered the question of whether such structures are only possible in pure water.

One can speculate that this proposed water structure plays a role in biological function. It is believed (Gewert et al, 2014) that bound water serves, in part, to facilitate activity at biological surfaces such as in cell membranes, intracellular organelles, proteins, and DNA/RNA. By connecting such helical structures to bound water an argument can be made, first, that proton-hopping plays a role at the water/biological interface, and second, that the orientation of these structures may be important to ~~the~~ kinetic processes occurring at the interface.

Finally, there is the possibility that because these putative water structures can carry electric signals, it is conceivable they may provide an additional means of information transfer within biological systems, similar in some respects to the role played by ion channels. One might expect to find, for example, versions of such structures closely resembling gap junctions between cells or perhaps even synaptic neurotransmitters, with the great advantage of carrying information much faster due to the intrinsic higher conductivity associated with proton-hopping.

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